

QUARTERLY PROGRESS REPORT

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Raytheon

SPONSORED BY:

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
DEFENSE SCIENCES OFFICE

RF VACUUM MICROELECTRONICS
ARPA ORDER No. 8162

ISSUED BY DARPA/CMO UNDER CONTRACT No. MDA972-91-C-0032

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QUARTERLY PROGRESS REPORT #1
(October 1 - December 31, 1991)

Sponsored by: Dr. Bertram Hui
DARPA/DSO
3701 North Fairfax Drive
Arlington, VA 22203
Tel.: (703) 696-2239

Monitored by:

Contractor: Raytheon Research Division
131 Spring Street
Lexington, MA 02143

Effective Date of Contract: September 18, 1991

Contract Expiration Date: March 15, 1993

Contract Amount: Basic: \$1,095,328
Options: \$ 640,090

Principal Investigator: Dr. Alan Palevsky
Tel: (617) 860-3079
FAX: (617) 860-3195

Title of Work: Research on RF Vacuum Microelectronics



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I. EXECUTIVE SUMMARY

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- Process for fabrication of moly tips has been perfected.
- Current densities of .5 amp/cm² on 95 K pixel array.
- Lifetime--many hours, days at reduced current.
- Modulation voltage--40 volts.
- Initial design for FEA cavity triode complete.

Cornell

- Fabricated new cone-shaped grid structure for FEA cathode; this is a self-aligned sub-micron-size grid electrode.
- Hired and trained postdoctoral fellow; he completed his first successful fabrication run.
- Presented paper at IEDM 1991.

II. MILESTONES STATUS

No milestones in this quarter.

III. TECHNICAL PROGRESS

Raytheon

Improvement in the tip fabrication process and the investigation of burn-in and test procedures have been the focus for the first three months of the contract.

The process development and improvement was an extension of internally funded work for flat panel displays. The mask set used was from this work. Since the basic tip process is not the limit to high frequency operation, using this mask set let us start work immediately. A variety of problems have been overcome or alleviated. These include gate/cathode leakage, tip height relative to the gate metal, yield, and cracking at metalization crossovers.

The burn-in and test of the tips also improved. A new hire (Ph.D level) is working full-time in this area. We also have a new fully instrumented test stand that includes bakeout capabilities, a turbo and vac-ion pumps, a residual gas analyzer, power supplies and other electronics. Bakeout and turn-on schedules have been developed that improve the FEA emission.

The mask set in use does not have a fully dense set of emitters. It is divided into pixels and has a packing density of about 12 percent. By measuring the total current and correcting for the packing density, a scaled current density can be calculated. The maximum current density we have attained is $.5 \text{ A/cm}^2$. At slightly lower current densities we have run the FEA cathode for many hours. The modulation voltage is about 40 volts and the anode voltage has been as high as 5 kV, while typically the tips are run at 2 kV. Some initial frequency measurements were performed. The capacitance of the test stand limited the maximum frequency to under one megahertz. We plan to add high frequency cabling to the stand.

The initial design for a cavity triode that uses an FEA cathode is complete, and the FEA cathode has been designed. The layout of this mask should be done in January with fabrication starting in February

N FISCAL STATUS

CONTRACT NO: MDA972-91-C-0032
 CONTR. TITLE: RF VACUUM MICROELECTRONICS
 CONTRACTOR: RAYTHEON CO., RESEARCH DIV.

DATE PREPARED:
 REPORT PERIOD:

14-Jan-92
 11/25/91 - 12/31/92

FUNDS AND MANHOUR EXPENDITURE REPORT

CONTRACT VALUE:	\$1,095,328
CURRENT FUNDING (cell):	\$762,000
NEG. FEE RATE:	0.0%

	CONTRACT VALUE	REPORTING MO. EXPEN- DITURES	CUMULATIVE EXPEND. TO DATE	% \$ VALUE	COST TO COMPLETE ESTIMATE	LATEST COST ESTIMATE	PREVIOUS COST ESTIMATE
A	B	C	D	E	F	G	H
TOTAL PRIME LABOR HOURS	7,467	287	933		\$,534	7,467	
TOTAL PRIME LABOR	\$203,891	\$7,846	\$28,459		\$175,432	\$203,891	0
LABOR OVERHEAD	\$362,926	\$13,966	\$50,860		\$312,286	\$362,926	0
TOTAL LABOR & OVERHEAD	\$566,817	\$21,812	\$79,119		\$487,698	\$566,817	0
MATERIALS	\$220,841	\$1,752	\$1,752		\$219,089	\$220,841	0
ODC	\$830	(\$4)	\$346		\$484	\$830	0
IMR	\$135,944	\$1,690	\$2,673		\$133,071	\$135,944	0
PRODUCT COST	\$924,432	\$25,240	\$84,090		\$840,342	\$924,432	0
G & A	\$148,407	\$4,229	\$14,097		\$134,310	\$148,407	0
COM	\$22,489	\$1,025	\$3,720		\$18,769	\$22,489	0
TOTAL COST LEVEL	\$1,095,328	\$30,494	\$101,907		\$993,421	\$1,095,328	0
FEE	\$0	\$0	\$0		\$0	\$0	0
TOTAL CONTRACT PRICE	\$1,095,328	\$30,494	\$101,907	9.30%	\$993,421	\$1,095,328	0
OUTSTANDING COMMIT.		\$124,131	\$124,131				
TOTAL COMMIT & EXPEND.	\$1,095,328	\$154,625	\$226,038	20.64%	\$993,421	\$1,095,328	0

EXPENDITURES THIS QUARTER: \$101,907

TOTAL EXPENDITURES TO DATE: \$101,907

PROJECTED EXPENDITURES:

01/92 - 03/92:	\$160,500
04/92 - 06/92:	\$175,000
07/92 - 09/92:	\$198,400
10/92 - 12/92:	\$215,100

TOTAL FY92 EXPENDITURES: \$635,807

1) IS CURRENT FUNDING SUFFICIENT (Y/N): YES

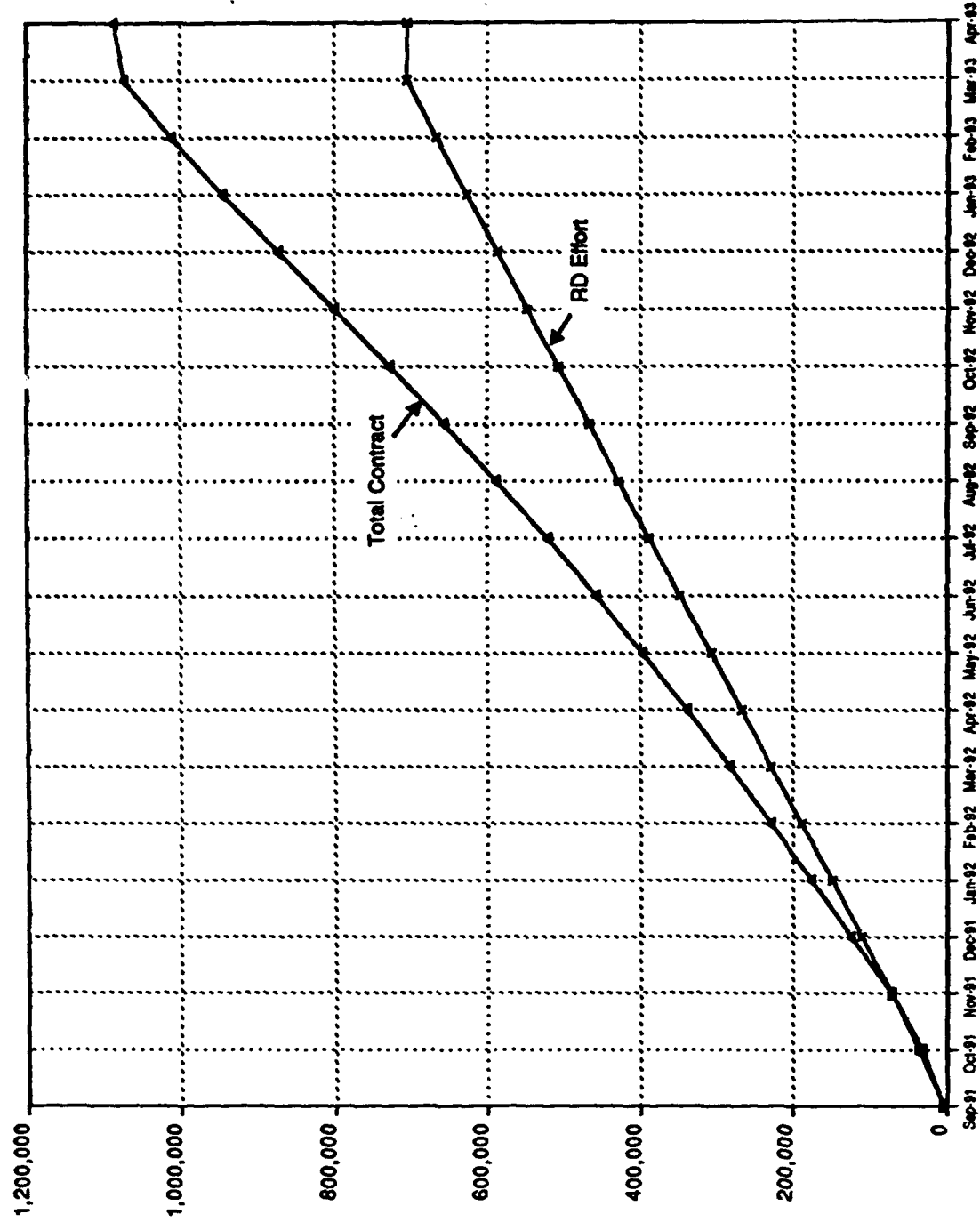
2) WHAT IS FY93'S FUNDING REQUIREMENT?: \$1,095,328

3) IS ALL DATA CROSS REFERENCED?: YES

RF Vacuum Microelectronics

Date	Actual	Budget	RD Effort
Sep-91	4,473	4,500	4,500
Oct-91	31,728	35,700	35,700
Nov-91	71,413	72,400	72,400
Dec-91	101,907	122,600	109,600
Jan-92		175,100	149,000
Feb-92		228,100	188,200
Mar-92		283,100	228,300
Apr-92		339,400	268,400
May-92		397,700	308,400
Jun-92		458,100	348,200
Jul-92		521,600	388,300
Aug-92		587,700	428,300
Sep-92		658,500	468,400
Oct-92		727,200	508,100
Nov-92		799,300	547,600
Dec-92		871,600	587,100
Jan-93		943,500	628,600
Feb-93		1,011,500	668,500
Mar-93		1,072,800	705,700
Apr-93		1,085,328	705,700

Funding @ TCL = \$762,000
Basic Value @ TCL = \$1,085,328



□ Actual ▲ Budget × RD Effort

V. PROBLEM AREAS

The original ring emitter discussed in the proposal had a limited lifetime. This led us to a design we call a "wing" structure. It is a vertical circular edge emitter. The process development has been slower than expected. We have not been able to make the structures as desired. We plan to continue this effort near-term over the next three months. Depending upon the results, we may decide to discontinue the effort and concentrate only on the tips.

VI. VISITS AND TECHNICAL PRESENTATIONS

Cornell University made a presentation at the 1991 IEDM meeting in Washington D.C., December 8-11. The latest results on the fabrication of the FEA cathodes was presented.

Raytheon

14 January 1992
JEG:9010:92:018

Defense Advanced Research Projects Agency
Contracts Management Office
3701 North Fairfax Dr., Rm. 927
Arlington, VA 22203-1714

Attention: Mr. Donald Sharkus
Subject: Contract No. MDA972-91-C-0032
Reference: CLIN C-2, Item 0002AA

Dear Mr. Sharkus:

Raytheon Company, Research Division, is pleased to submit herewith the First Quarterly Report for the subject contract. This report has been prepared in accordance with the referenced line item as annotated by technical discussions with Dr. B. Hui. This report covers the period from 16 September through 31 December 1991.

If you should have any questions, please contact the undersigned at (617) 860-3134.

Sincerely yours,



John E. Greene, Jr.
Contract Specialist

cc: Defense Advanced Research Projects Agency
Attn: Dr. Bertram H. Hui, DARPA/DSO
(1 copy)

Attn: Ms. Claire P. Ricaurte, DARPA/DSO
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Dr. A. Palevsky